



# MULTIPYCNOMETER

QUALITY ASSURANCE  
AND  
SERVICE

***MANUAL***

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## **1.0. PURPOSE**

1.1. THE REQUIREMENTS SPECIFIED HEREIN ARE INTENDED TO ASSURE THAT MULTIPYCNOMETERS WITH MODEL NUMBER MVP-3 MEET OR EXCEED THE REQUIRED MANUFACTURING AND QUALITY ASSURANCE STANDARDS AS SPECIFIED IN THE COMPANY QUALITY MANUAL.

## **2.0. SCOPE**

2.1. THIS PROCEDURE IS TO BE FOLLOWED BY ALL QUALITY ASSURANCE PERSONNEL INVOLVED WITH MULTIPYCNOMETER TEST AND CALIBRATION PROCEDURES.

2.2. THIS PROCEDURE CONTAINS CALIBRATION GUIDELINES THAT CAN ALSO BE FOLLOWED BY QUALIFIED TECHNICIANS, INCLUDING QUANTACHROME CUSTOMERS, AGENTS AND SALES PEOPLE.

2.3. THESE REQUIREMENTS APPLY TO OTHER MULTIPYCNOMETER MODELS WITH MODIFICATIONS OUTLINED IN APPENDIX A.

## **3.0. DEFINITIONS**

3.1. MULTIPYCNOMETER: APPARATUS DESIGNED TO MEASURE TRUE SOLID VOLUMES BY A GAS EXPANSION TECHNIQUE KNOWN AS HELIUM PYCNOMETRY [ 1 , 2 ].

3.2. QUALITY ASSURANCE: FULL COMPLIANCE WITH PROCEDURES AND STANDARDS ITEMIZED IN THE COMPANY QUALITY MANUAL.

3.3. SERVICE: GUIDELINES PROVIDED TO ENABLE SERVICE TECHNICIANS TO HANDLE INSTRUMENT TROUBLESHOOTING.

3.4. MVP - i : MULTIPLE VOLUME PYCNOMETER, MODEL -i .

3.5. VR : KNOWN MANIFOLD REFERENCE VOLUME IN CC'S [ 2 ].

3.6. VC : CELL VOLUME IN CC'S.

3.7. VP: SPHERE OR SAMPLE VOLUME IN CC'S.

3.8. PRESSURE: ALL PRESSURE READINGS ARE DISPLAYED ON THE DIGITAL PANEL METER AND ARE GIVEN IN PSIG (POUNDS PER SQUARE INCH GAUGE PRESSURE).

3.9. SPHERES: STAINLESS STEEL BALLS OF VARIOUS SIZES ARE USED FOR VOLUME CALIBRATIONS. ALL SPHERE VOLUMES ARE GIVEN IN CUBIC CENTIMETERS (CC'S).

3.10. TOGGLE VALVE: TOGGLE VALVES ARE ON / OFF VALVES LABELED I, II, GAS IN AND GAS OUT ON THE INSTRUMENT PANEL FACE. VALVES ARE CLOSED WHEN THEIR HANDLES ARE PARALLEL TO THE CABINET FACE AND OPEN WHEN PERPENDICULAR TO THE CABINET FACE.

3.11. NEEDLE VALVE: TWO ADJUSTABLE NEEDLE VALVES PERMIT FLOW RATE CONTROL THROUGH GAS IN AND GAS OUT. TURNING THEIR KNOB CLOCKWISE REDUCES THEIR RESPECTIVE FLOW RATES.

3.12. CORCOM: FUSED ELECTRICAL RECEPTACLE USED TO CONFIGURE THE INPUT POWER FOR 100,120, 220, OR 240VAC. THE RECEPTACLE IS LOCATED ON THE INSTRUMENT'S BACK PANEL.

3.13. SELECTOR VALVE: TWO - POSITION BALL VALVE LOCATED ON THE MULTIPYCNOMETER'S CABINET FACE FOR SWITCHING BETWEEN POSITIONS LABELED CELL AND REFERENCE.

#### **4.0. RESPONSIBILITIES**

4.1. THE FOLLOWING PROCEDURE SHALL BE PERFORMED ONLY BY INDIVIDUALS TRAINED AS ELECTRICAL AND MECHANICAL TECHNICIANS.

4.2. QUANTACHROME TECHNICIANS SHALL BE FULLY TRAINED ON ELECTRICAL PROCEDURES, MECHANICAL ASSEMBLY, AND GAS HANDLING OPERATIONS AS OUTLINED IN THE COMPANY QUALITY MANUAL.

4.3. TECHNICIANS WILL HAVE AVAILABLE THE FOLLOWING EQUIPMENT REQUIRED FOR TESTING.

4.3.1. CALIBRATED 4 1/2 DIGITAL VOLTMETER WITH OHMS, AC-250VAC AND DC 24VDC.

4.3.2. ULTRA HIGH PURITY (99.999%) HELIUM WITH A TWO STAGE REGULATOR SET TO DELIVER AT LEAST 25 PSIG OF PRESSURE.

4.3.3. 5/16 HEX ALLEN WRENCH.

4.3.4. STANDARD HAND TOOLS.

4.3.5. JEWELER'S SCREWDRIVER.

4.3.6. CALIBRATED PRESSURE GAUGE TO READ 25 +/- 0.25 PSIG.

4.3.7. BEAKER HALF FULL OF WATER.

4.3.8. TORQUE SEAL.

4.4. THE QUALITY ASSURANCE MANAGER WILL CONFIRM THAT QUANTACHROME TECHNICIANS FOLLOW ALL PROCEDURES IN COMPLIANCE WITH THE GUIDELINES STATED IN THE COMPANY QUALITY MANUAL.

4.5. THE PRODUCT MANAGER WILL EVALUATE ALL REVISIONS TO THIS DOCUMENT TO ENSURE COMPLIANCE WITH ENGINEERING DESIGN REQUIREMENTS.

## **5.0. REQUIREMENTS**

### **5.1. ELECTRICAL AND MECHANICAL INSPECTION**

#### **5.1.1 ELECTRICAL**

5.1.1.1 WIRING - VERIFY THAT ALL WIRING CONTINUITY CONFORMS TO THE LATEST REVISION DRAWING

5.1.1.2. VISUALLY INSPECT THE DIGITAL PANEL METER CONNECTOR FOR CORRECT WIRING AND ALL SOLDERING FOR COLD JOINTS.

5.1.1.3. VERIFY THAT TWO 2 AMP FUSES ARE INSTALLED IN THE CORCOM. REMOVE THE FUSE BY SLIDING THE BLACK HANDLE IN THE CORCOM TO THE LEFT. REINSTALL THE FUSES IF THE AMPERAGE IS CORRECT.

5.1.1.4. RECONFIGURE THE CORCOM TO MATCH THE VOLTAGE REQUIRED FOR THE CUSTOMER ORDER (FUSED ELECTRICAL RECEPTACLE) FOR 120 VAC. PUSH THE PLASTIC SHIELD TO THE LEFT,

5.1.1.5. THE NEW CORCOM HAS A BARREL TYPE VOLTAGE ADJUSTMENT. DO NOT SPIN THE BARREL OR YOU MAY DAMAGE THE CONTACTS. PULL OUT THE BARREL AND ROTATE THE BARREL TO THE SPECIFIED CUSTOMER VOLTAGE REQUIREMENT.

### **5.1.2. MECHANICAL**

5.1.2.1. VERIFY THAT ALL FRONT PANEL KNOBS ROTATE FREELY AND THAT THE ZERO KNOB HAS A NYLON WASHER PLACED BEHIND IT.

5.1.2.2. VERIFY THAT THE SAMPLE CELL HOLDER COVER AND ITS RECEPTOR IN THE INSTRUMENT'S COVER PANEL HAVE CLEARLY VISIBLE WHITE ALIGNMENT LINES (FIDUCIARY MARKS). ALSO VERIFY THAT THE COVER SCREWS FREELY ONTO THE RECEPTOR, AND THAT WHEN FULLY TIGHTENED IT IS NOT IN CONTACT WITH THE BLACK BULKHEAD RETAINER.

5.1.2.3. REMOVE THE 2-INCH O-RING (PART NUMBER 51000-032) FROM UNDER THE SAMPLE CELL HOLDER COVER. CLEAN THE COVER AND THE BRASS CELL HOLDER SEAT. APPLY A VERY LIGHT COAT OF VACUUM GREASE TO THE O-RING AND REINSTALL IT IN THE CELL COVER.

5.1.2.4. INSPECT THE SAMPLE CELL HOLDER TO MAKE SURE THAT IT HAS NO SCRATCHES AND VERIFY THAT THE GAS INLET GROOVE IS CLEAN, FREE OF DIRT AND THAT ITS FLOW PATH IS UNRESTRICTED.

5.1.2.5. VERIFY THAT ALL FITTINGS ARE SET ON TIGHTLY AND THAT ALL SOLDER JOINTS ARE CLEAN, NOT COLD AND HAVE SHRINKABLE CLEAR TUBING OVER THEM.

5.1.2.6. VERIFY THAT TWO PLASTIC TIES ARE WRAPPED AROUND BOTH THE BIMBA BRAND AIR CHAMBER AND THE BRASS CELL HOLDER IN ORDER TO TIE BOTH TOGETHER.

5.1.2.7. CLEAN ALL SPHERES, SAMPLE CELL CUPS AND SLEEVES WITH ISOPROPYL AND A LINT-FREE TISSUE.

5.1.2.8. VERIFY THAT ALL THE SAMPLE CELL CUPS FIT SNUGLY INTO THEIR SLEEVES AND THAT ALL SLEEVES FIT INTO THE BRASS SAMPLE CELL HOLDER.

## 5.2. POWER CHECKS

### 5.2.1. AC CHECKS

5.2.1.1. CAUTION -THESE CHECKS MUST BE PERFORMED WITH THE POWER SWITCH TURNED OFF AND WITH THE POWER CORD UNPLUGGED. THESE INSTRUCTIONS SHOULD ONLY BE PERFORMED BY TRAINED PERSONNEL AND THEN ONLY AFTER TAKING ALL PERTINENT SAFETY PRECAUTIONS.

5.2.1.2. SET THE POWER SWITCH TO THE *OFF* POSITION AND CONFIGURE THE CORCOM FOR 120 VAC OR TO THE SPECIFIED CUSTOMER VOLTAGE REQUIREMENT. THE CORCOM CARD IS LOCATED BEHIND THE CLEAR PLASTIC SLIDE DOOR NEXT TO THE POWER SOCKET. TO CHANGE THE VOLTAGE SETTINGS, SLIDE THE DOOR AND REMOVE THE CARD USING PLIERS. HOLD THE CARD SO THAT THE VOLTAGE YOU ARE CONFIGURING THE UNIT FOR FACES YOU, AND SLIDE THE CARD BACK IN THE SLOT.

5.2.1.3. USING AN OHM METER, TEST FOR CONTINUITY ACROSS THE LINE INPUT TERMINALS. THE READING SHOULD BE INFINITY (OPEN CIRCUIT).

5.2.1.4. USING AN OHM METER, TEST FOR CONTINUITY BETWEEN THE INPUT LINE TERMINALS AND THE CHASSIS GROUND. THE READING SHOULD BE INFINITY (OPEN CIRCUIT).

5.2.1.5. USING AN OHM METER, TEST FOR CONTINUITY BETWEEN THE INPUT GROUND TERMINALS AND THE CHASSIS GROUND. VERIFY A READING OF CONTINUITY INDICATING A SHORT CIRCUIT.

5.2.1.6. SET THE POWER SWITCH TO ON. USING AN OHM METER, TEST ACROSS THE LINE INPUT TERMINALS. THE READING SHOULD BE AROUND 17 OHMS. IF A SHORT IS READ THE SWITCH MAY BE WIRED INCORRECTLY. THE READING SHOULD BE AROUND 68 OHMS IF THE VOLTAGE IS 220V-240V.

### **5.3.2.2. DC POWER -ON CHECKS**

5.2.2.1. REMOVE THE PRESSURE TRANSDUCER CONNECTOR FROM THE SMALL PRINTED CIRCUIT BOARD (PART NUMBER 00003) LOCATED INSIDE ON THE LEFT BULKHEAD.

5.2.2.2. CONNECT THE INSTRUMENT TO THE 120 VAC SUPPLY OUTLET (OR TO THE CUSTOMER REQUIRED VOLTAGE) AND TURN THE POWER SWITCH TO THE “ON” POSITION.

5.2.2.3. USING A CALIBRATED DIGITAL VOLT METER, CHECK AND ADJUST THE POWER SUPPLY FOR DC OUTPUT VOLTAGE SUPPLIED TO THE CIRCUIT CARD. THE READINGS ARE TAKEN AT THE POWER SUPPLY TERMINALS AND ARE REFERENCED TO THE NEUTRAL POST. THESE READINGS SHOULD BE  $+24.00 \pm 0.01\text{VDC}$  AT THE POST RED & YELLOW AND  $+5.00 \pm 0.01\text{VDC}$  AT THE POST COM. & ORG.

5.2.2.4. CONNECT THE VOLTMETER LEADS TO THE PRESSURE TRANSDUCER PLUG ON THE SMALL PRINTED CIRCUIT BOARD AND VERIFY THAT  $+24 \pm 0.01\text{VDC}$  ARE MEASURED ACROSS PINS 4 AND 6.

5.2.2.5. TURN THE POWER SWITCH TO OFF AND THEN RECONNECT THE PRESSURE TRANSDUCER CONNECTOR TO THE SMALL PRINTED CIRCUIT BOARD.

## **5.3. ALIGNMENTS**

### **5.3.1. DIGITAL PANEL METER**

5.3.1.1. TURN THE INSTRUMENT’S POWER SWITCH TO ON. VERIFY THAT THE DIGITAL PANEL DISPLAYS NUMBERS THAT ARE BRIGHT AND CLEAR.

5.3.1.2. TURN THE ZERO ADJUSTMENT KNOB ON THE FRONT PANEL FROM STOP TO STOP SLOWLY AND VERIFY THAT SMOOTH DIGITAL CHANGES OCCUR AND THAT ALL SEGMENTS OF EACH DIGIT ILLUMINATE.

5.3.1.3. TURN THE ZERO ADJUSTMENT KNOB ON THE FRONT PANEL TO THE MID-RANGE POSITION (5 TURNS FROM THE STOP FOR A TYPICAL 10 TURN POTENTIOMETER).

5.3.1.4. TURN THE SELECTOR VALVE TO THE CELL POSITION AND OPEN THE GAS OUT TOGGLE VALVE TO VENT THE CELL. AFTER 5 MINUTES OF WARM UP TIME ADJUST RESISTOR R1 LOCATED ON THE SMALL PRINTED CIRCUIT BOARD FOR A READING OF 0.000 PSIG ON THE DIGITAL PANEL METER. THIS IS PERFORMED BY PLACING A JEWELER’S SCREWDRIVER THROUGH THE HOLE IN THE BACK PANEL AND TURNING THE POTENTIOMETER UNTIL THE DIGITAL PANEL METER READING DISPLAYS 0.000 PSIG.

5.3.1.5. PLACE A SMALL AMOUNT OF TORQUE SEAL BETWEEN THE ADJUSTMENT KNOB AND THE BODY OF THE POTENTIOMETER R1 TO INSURE THAT IT REMAINS UNCHANGED DURING SHIPMENT.



### 5.3.2 Texmate DI-50E Panel Meter Setup

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#### STEP A CODE SETUP: Instrument Model No. MVP-DI50E (Multi- Pycnometer)

- 5.3.2.1 Press **Program** and **Up-arrow** at the same time:  
This enters the **main programming mode**. Display toggles between [**bri**] and [**5**].  
Press **Program** to set **bri** to **5**. If **bri** is not set to **5** then use **up/ down arrow** and set **bri** to **5**.
- 5.3.2.2 Press **Program** button  
Display toggles between [**CAL**] and [**000**].
- 5.3.2.3 Press **Program** button again  
Display toggles between [**Cod\_1**] and [**000**].  
Change **Cod\_1** to **001** for model#24000-2-0-D. Enter **061** for model#20033-1
- 5.3.2.4 Press **Program** button  
Display toggles between [**DiSP**] and [**003**].  
Change **DiSP** to **004**. (This will move the decimal)
- 5.3.2.5 Press **Program** button  
Display toggles between [**Cod\_1**] and [**061**]  
Change **Cod\_1** to **000**.
- 5.3.2.6 Press **Program** button  
Display toggles between [**Cod\_2**] and [**XXX**]  
Change **Cod\_2** to **001**.
- 5.3.2.7 Press **Program** button  
Display toggles between [**Cod\_3**] and [**XXX**]  
Change **Cod\_3** to **000**.
- 5.3.2.8 Press **Program** button  
Display toggles between [**Cod\_4**] and [**XXX**]     Note: Set **Cod\_4** to **000** for 60 Hz  
Change **Cod\_4** to **000**.     Set **Cod\_4** to **001** for 50 Hz
- 5.3.2.9 Press **Program** button  
Display toggles between [**Cod\_5**] and [**XXX**]  
Change **Cod\_5** to **000**.
- 5.3.2.10 Press **Program** button until you have reached Cod\_8.  
Display toggles between [**Cod\_8**] and [**XXX**]  
Change **Cod\_8** to **002**.
- 5.3.2.11 Press **Program** button  
Display toggles between [**Cod\_9**] and [**XXX**]  
Change **Cod\_9** to **000**.
- 5.3.2.12 Press **Program** button  
Display will indicate instrument's current pressure.  
Verify the decimal is set as **XX.XXX**

5.3.2.13 Press **Program** and **Down-arrow** at the same time:

This enters the **setpoint-programming mode**.

Display toggles between [**SP\_1**] and [**50000**]. 18.xxx for the new model

5.3.2.14 Press the Program button repeatedly until the

Display toggles between [**SP\_5**] and [**30000**], 10000 for the new model.

Change **SP\_5** to **1.000**

Note: If SP\_5 is unavailable, perform the next step (SPC\_5) then come back to this step; Ensure SPC\_5 is set to [000].

You should now be able to set up SP\_5 to 1.000. Continue and perform the next step before locking the meter.

5.3.2.15 Press Program button repeatedly until the

Display toggles between [**SPC\_5**] and [**000**].

Change **SPC\_5** to **46**.

5.3.2.16 Check all the setting before lock

#### **STEP B LOCK CODE SETUP:**

5.3.2.17 Loosen the meter from cabinet.

5.3.2.18 Remove black face meter bezel.

5.3.2.18 Set both **DIP** Switches from **OFF** to **ON** position.

5.3.2.20 Reinstall the bezel and secure the meter.

### **5.3.3. PRESSURE RELIEF VALVE**

5.3.3.1. USING 1/8 INCH COPPER TUBING, CONNECT THE CALIBRATED PRESSURE GAUGE BETWEEN THE HELIUM TANK AND THE GAS INPUT SWAGELOCK CONNECTION LOCATED ON THE SIDE OF THE STEREOPYCNOMETER .

5.3.3.2. THE PRESSURE RELIEF VALVE IS LOCATED IMMEDIATELY BEFORE THE INPUT FLOW CONTROL NEEDLE VALVE INSIDE THE STEREOPYCNOMETER. ADJUSTMENTS WILL BE MADE SO THE PRESSURE IS RELIEVED IF THE TANK PRESSURE EXCEEDS 25 PSIG. AT 25 PSIG THE RELIEF VALVE WILL ACTUATE AND THE GAS WILL BE VENTED, AFTER WHICH REMOVE THE GAS INPUT LINE MOMENTARILY TO ALLOW THE PRESSURE RELIEF VALVE TO RESET

5.3.3.3. USING A 5/16 HEX ALLEN WRENCH, SET THE RELIEF VALVE TO JUST STOP AT 25 PSIG. CHECK THE SETTING BY SUBMERGING THE END OF THE RELIEF VALVE IN A BEAKER OF WATER, IN ORDER TO VERIFY THAT NO BUBBLES ARE FORMED AT 25 PSIG. INCREASE THE TANK PRESSURE AS DISPLAYED ON THE CALIBRATED PRESSURE GAUGE TO 26 PSIG AND VERIFY THAT BUBBLES APPEAR IN THE BEAKER.

5.3.3.4. TIGHTEN THE OUTER LOCKING NUT UNTIL IT MEETS THE INNER NUT. APPLY A MODERATE AMOUNT OF TORQUE SEAL TO THE OUTER NUT. NOTE THAT AN EXCESSIVE AMOUNT OF TORQUE SEAL WILL BLOCK THE RELIEF VALVE.

5.3.3.5. ADJUST THE TANK PRESSURE REGULATOR TO DELIVER SLIGHTLY ABOVE 20 PSIG.

## 5.4. LEAK TEST

### 5.4.1. PURGE

5.4.1.1. THE PROCEDURE TO PURGE THE INSTRUMENT (BY FLOWING HELIUM TO REMOVE CONTAMINANTS) NEEDS TO BE PERFORMED PRIOR TO TESTING NEW INSTRUMENTS AND INSTRUMENTS THAT HAD BEEN TURNED OFF FOR MORE THAN ONE DAY. THERE IS NO NEED TO REPEAT THIS PROCEDURE BETWEEN THE CELL AND REFERENCE CALIBRATIONS.

5.4.1.2. INSTALL THE TWO MICRO STAINLESS STEEL BALLS INTO THE SAMPLE CELL AND THEN THE SAMPLE CELL INTO THE MICRO SLEEVE. PLACE THE FILLED SLEEVE INTO THE CELL HOLDER AND THEN CLOSE THE CELL HOLDER COVER. SET GAS IN NEEDLE VALVE TO 0 BY ADJUSTING KNOB AND SET SCREW.

5.4.1.3. OPEN THE GAS OUT TOGGLE VALVE AND THE GAS OUT NEEDLE VALVE.

5.4.1.4. SET THE SELECTOR VALVE TO THE CELL POSITION.

5.4.1.5. OPEN BOTH TOGGLE VALVES I AND II ON THE FRONT PANEL.

5.4.1.6. OPEN THE GAS IN TOGGLE VALVE AND ADJUST THE GAS IN NEEDLE VALVE FOR A 1 PSIG PURGE RATE AS DISPLAYED ON THE DIGITAL PANEL METER.

5.4.1.7. PURGE THE MULTIPYCNOMETER FOR 30 MINUTES BEFORE CONTINUING TO STEP 5.4.2. CLOSE THE GAS IN TOGGLE VALVE WHEN THE PURGE TIME IS COMPLETED.

## 5.4.2. MICRO REFERENCE

5.4.2.1. FOLLOWING A SUITABLE PURGE (SEE ITEM 5.4.1.1), INSTALL THE MICRO SAMPLE CELL AND SLEEVE WITH TWO MICRO STAINLESS STEEL BALLS INTO THE CELL HOLDER AND CLOSE THE COVER. PURGE THE INSTRUMENT FOR AN ADDITIONAL MINUTE TO REMOVE ALL AIR WITHIN IT.

5.4.2.2. CLOSE THE TOGGLE VALVES I, II AND GAS IN.

5.4.2.3. TURN THE SELECTOR VALVE ON THE FRONT PANEL TO THE CELL POSITION AND THEN OPEN THE GAS OUT TOGGLE VALVE.

5.4.2.4. TURN THE ZERO ADJUSTMENT KNOB ON THE FRONT PANEL UNTIL A 0.000 PSIG READING IS DISPLAYED ON THE DIGITAL PANEL METER.

5.4.2.5. TURN THE SELECTOR VALVE TO THE REFERENCE POSITION AND CLOSE THE GAS OUT TOGGLE VALVE.

5.4.2.6. OPEN THE GAS IN TOGGLE VALVE AND, WHEN THE DIGITAL PANEL METER READS 19.0 PSIG, CLOSE THE GAS IN TOGGLE VALVE.

5.4.2.7. RECORD THE FIRST STABLE READING AS THE STARTING PRESSURE AND ENTER THAT READING ON THE INSTRUMENT CHECK SHEET IN APPENDIX B.1, ITEM B.1.3.7. AS THE STARTING PRESSURE FOR MICRO. THIS WILL SIGNAL THE BEGINNING OF A 1 MINUTE LEAK TEST.

5.4.2.8. AFTER 1 MINUTE HAS ELAPSED, RECORD THE READING AS DISPLAYED ON THE DIGITAL PANEL METER AND ENTER THAT READING AS PRESSURE AFTER 1 MINUTE FOR MICRO ON THE INSTRUMENT CHECK SHEET IN APPENDIX B.1, ITEM B.1.3.7. THE CALCULATED LEAK RATE MUST BE NO GREATER THAN 0.004 PSIG IN ONE MINUTE BEFORE PROCEEDING.

### 5.4.3. SMALL REFERENCE

5.4.3.1. FOLLOWING A SUITABLE PURGE (SEE ITEM 5.4.1.1), INSTALL THE MICRO SAMPLE CELL AND SLEEVE WITH TWO MICRO STAINLESS STEEL BALLS INTO THE CELL HOLDER AND CLOSE THE COVER. PURGE THE INSTRUMENT FOR AN ADDITIONAL MINUTE TO REMOVE ALL AIR WITHIN IT.

5.4.3.2. CLOSE ALL THE TOGGLE VALVES ON THE INSTRUMENT 'S FRONT PANEL. THEN, OPEN TOGGLE VALVE II.

5.4.3.3. TURN THE SELECTOR VALVE ON THE FRONT PANEL TO THE CELL POSITION AND THEN OPEN THE GAS OUT TOGGLE VALVE.

5.4.3.4. TURN THE ZERO ADJUSTMENT KNOB ON THE FRONT PANEL UNTIL A 0.000 PSIG READING IS DISPLAYED ON THE DIGITAL PANEL METER.

5.4.3.5. TURN THE SELECTOR VALVE TO THE REFERENCE POSITION AND CLOSE THE GAS OUT TOGGLE VALVE.

5.4.3.6. OPEN THE GAS IN TOGGLE VALVE AND, WHEN THE DIGITAL PANEL METER READS 19.0 PSIG, CLOSE THE GAS IN TOGGLE VALVE.

5.4.3.7. RECORD THE FIRST STABLE READING AS THE STARTING PRESSURE AND ENTER THAT READING ON THE INSTRUMENT CHECK SHEET IN APPENDIX B.1, ITEM B.1.3.7. AS THE STARTING PRESSURE FOR SMALL. THIS WILL SIGNAL THE BEGINNING OF A 1 MINUTE LEAK TEST.

5.4.3.8. AFTER 1 MINUTE HAS ELAPSED, RECORD THE READING AS DISPLAYED ON THE DIGITAL PANEL METER AND ENTER THAT READING AS PRESSURE AFTER 1 MINUTE FOR SMALL ON THE INSTRUMENT CHECK SHEET IN APPENDIX B.1, ITEM B.1.3.7. THE CALCULATED LEAK RATE MUST BE NO GREATER THAN 0.004 PSIG IN ONE MINUTE BEFORE PROCEEDING.

### 5.4.4. LARGE REFERENCE

5.4.4.1. FOLLOWING A SUITABLE PURGE (SEE ITEM 5.4.1.1), INSTALL THE MICRO SAMPLE CELL AND SLEEVE WITH TWO MICRO STAINLESS STEEL BALLS INTO THE CELL HOLDER AND CLOSE THE COVER. PURGE THE INSTRUMENT FOR AN ADDITIONAL MINUTE TO REMOVE ALL AIR WITHIN IT.

5.4.4.2. OPEN BOTH TOGGLE VALVES I AND II. CLOSE THE GAS IN TOGGLE VALVE.

5.4.4.3. TURN THE SELECTOR VALVE ON THE FRONT PANEL TO THE CELL POSITION AND THEN OPEN THE GAS OUT TOGGLE VALVE.

5.4.4.4. TURN THE ZERO ADJUSTMENT KNOB ON THE FRONT PANEL UNTIL A 0.000 PSIG READING IS DISPLAYED ON THE DIGITAL PANEL METER.

5.4.4.5. TURN THE SELECTOR VALVE TO THE REFERENCE POSITION AND CLOSE THE GAS OUT TOGGLE VALVE.

5.4.4.6. OPEN THE GAS IN TOGGLE VALVE AND, WHEN THE DIGITAL PANEL METER READS 19.0 PSIG, CLOSE THE GAS IN TOGGLE VALVE.

5.4.4.7. RECORD THE FIRST STABLE READING AS THE STARTING PRESSURE AND ENTER THAT READING ON THE INSTRUMENT CHECK SHEET IN APPENDIX B.1, ITEM B.1.3.7. AS THE STARTING PRESSURE FOR LARGE. THIS WILL SIGNAL THE BEGINNING OF A 1 MINUTE LEAK TEST.

5.4.4.8. AFTER 1 MINUTE HAS ELAPSED, RECORD THE READING AS DISPLAYED ON THE DIGITAL PANEL METER AND ENTER THAT READING AS PRESSURE AFTER 1 MINUTE FOR LARGE ON THE INSTRUMENT CHECK SHEET IN APPENDIX B.1, ITEM B.1.3.7. THE CALCULATED LEAK RATE MUST BE NO GREATER THAN 0.004 PSIG IN ONE MINUTE BEFORE PROCEEDING.

#### **5.4.5. CELL SECTION**

5.4.5.1. FOLLOWING A SUITABLE PURGE (SEE ITEM 5.4.1.1), INSTALL THE MICRO SAMPLE CELL AND SLEEVE WITH TWO MICRO STAINLESS STEEL BALLS INTO THE CELL HOLDER AND CLOSE THE COVER. PURGE THE INSTRUMENT FOR AN ADDITIONAL MINUTE TO REMOVE ALL AIR WITHIN IT.

5.4.5.2. CLOSE ALL THE TOGGLE VALVES.

5.4.5.3. TURN THE SELECTOR VALVE ON THE FRONT PANEL TO THE CELL POSITION AND THEN OPEN THE GAS OUT TOGGLE VALVE.

5.4.5.4. TURN THE ZERO ADJUSTMENT KNOB ON THE FRONT PANEL UNTIL A 0.000 PSIG READING IS DISPLAYED ON THE DIGITAL PANEL METER. CLOSE THE GAS OUT TOGGLE VALVE. TURN THE SELECTOR VALVE TO REFERENCE.

5.4.5.5. OPEN THE GAS IN TOGGLE VALVE AND, WHEN THE DIGITAL PANEL METER READS 19.0 PSIG, CLOSE THE GAS IN TOGGLE VALVE.

5.4.5.6. RECORD THE FIRST STABLE READING AS THE STARTING PRESSURE AND ENTER THAT READING ON THE INSTRUMENT CHECK SHEET IN APPENDIX B.1, ITEM B.1.3.7. AS THE STARTING PRESSURE FOR CELL. THIS WILL SIGNAL THE BEGINNING OF A 1 MINUTE LEAK TEST.

5.4.5.7. AFTER 1 MINUTE HAS ELAPSED, RECORD THE READING AS DISPLAYED ON THE DIGITAL PANEL METER AND ENTER THAT READING AS PRESSURE AFTER 1 MINUTE FOR CELL ON THE INSTRUMENT CHECK SHEET IN APPENDIX B.1, ITEM B.1.3.7. THE CALCULATED LEAK RATE MUST BE NO GREATER THAN 0.004 PSIG IN ONE MINUTE BEFORE PROCEEDING.

#### **5.4.6. FOUR WAY VALVE SECTION**

5.4.6.1. FOLLOWING A SUITABLE PURGE (SEE ITEM 5.4.1.1), INSTALL THE MICRO SAMPLE CELL AND SLEEVE WITH TWO MICRO STAINLESS STEEL BALLS INTO THE CELL HOLDER AND CLOSE THE COVER. PURGE THE INSTRUMENT FOR AN ADDITIONAL MINUTE TO REMOVE ALL AIR WITHIN IT.

5.4.6.2. CLOSE ALL THE TOGGLE VALVES.

5.4.6.3. TURN THE SELECTOR VALVE ON THE FRONT PANEL TO THE CELL POSITION AND THEN OPEN THE GAS OUT TOGGLE VALVE.

5.4.6.4. TURN THE ZERO ADJUSTMENT KNOB ON THE FRONT PANEL UNTIL A 0.000 PSIG READING IS DISPLAYED ON THE DIGITAL PANEL METER.

5.4.6.5. TURN THE SELECTOR VALVE TO THE REFERENCE POSITION AND CLOSE THE GAS OUT TOGGLE VALVE.

5.4.6.6. OPEN THE GAS IN TOGGLE VALVE AND, WHEN THE DIGITAL PANEL METER READS 19.0 PSIG, CLOSE THE GAS IN TOGGLE VALVE.

5.4.6.7. RECORD THE FIRST STABLE READING AS THE STARTING PRESSURE AND ENTER THAT READING ON THE INSTRUMENT CHECK SHEET IN APPENDIX B.1, ITEM B.1.3.7. AS THE STARTING PRESSURE FOR FOUR WAY. THIS WILL SIGNAL THE BEGINNING OF A 1 MINUTE LEAK TEST.

5.4.6.8. AFTER 1 MINUTE HAS ELAPSED, RECORD THE READING AS DISPLAYED ON THE DIGITAL PANEL METER AND ENTER THAT READING AS PRESSURE AFTER 1 MINUTE FOR FOUR WAY ON THE INSTRUMENT CHECK SHEET IN APPENDIX B.1, ITEM B.1.3.7. THE CALCULATED LEAK RATE MUST BE NO GREATER THAN 0.004 PSIG IN ONE MINUTE BEFORE PROCEEDING.

## **5.5. CALIBRATION**

### **5.5.1. PURGE**

5.5.1.1. INSTALL THE SAMPLE CELL YOU ARE INTENDING TO CALIBRATE (LARGE, SMALL OR MICRO CELL) AND CLOSE THE CELL HOLDER COVER.

5.5.1.2. OPEN THE GAS OUT TOGGLE VALVE AND THE GAS OUT NEEDLE VALVE.

5.5.1.3. TURN THE SELECTOR VALVE ON THE FRONT PANEL TO THE CELL POSITION.

5.5.1.4. OPEN BOTH TOGGLE VALVES I AND II.

5.5.1.5. OPEN THE GAS IN TOGGLE VALVE AND ADJUST THE GAS IN NEEDLE VALVE FOR A 1 PSIG PURGE RATE AS DISPLAYED ON THE DIGITAL PANEL METER.

5.5.1.6. PURGE THE MULTIPYCNOMETER FOR 5 MINUTES BEFORE CONTINUING. CLOSE THE GAS IN TOGGLE VALVE WHEN THE PURGE TIME IS COMPLETED.



## 5.5.2. VRa LARGE CALIBRATION (NO SPHERES, LARGE CELL)

5.5.2.1. PERFORM THE STEPS LISTED IN SECTION 5.5.1 (THE PURGE ROUTINE) WITH THE LARGE SAMPLE CELL IN THE CELL HOLDER.

5.5.2.2. OPEN THE TOGGLE VALVES I AND II AND CLOSE THE GAS IN TOGGLE VALVE.

5.5.2.3. TURN THE SELECTOR VALVE ON THE FRONT PANEL TO THE CELL POSITION AND THEN OPEN THE GAS OUT TOGGLE VALVE.

5.5.2.4. TURN THE ZERO ADJUSTMENT KNOB ON THE FRONT PANEL UNTIL A 0.000 PSIG READING IS DISPLAYED ON THE DIGITAL PANEL METER.

5.5.2.5. TURN THE SELECTOR VALVE TO THE REFERENCE POSITION AND CLOSE THE GAS OUT TOGGLE VALVE.

5.5.2.6. OPEN THE GAS IN TOGGLE VALVE AND, WHEN THE DIGITAL PANEL METER READS 17.0 PSIG, CLOSE THE GAS IN TOGGLE VALVE.

5.5.2.7. VERIFY THAT THE PRESSURE DISPLAYED ON THE DIGITAL PANEL METER DOES NOT CHANGE DURING A 10-SECOND PERIOD. TAKE THE aP1 PRESSURE READING ON THE DIGITAL PANEL METER AND ENTER THAT NUMBER ON THE INSTRUMENT CALIBRATION SHEET IN APPENDIX B.2, ITEM B.2.3., AS aP1.

5.5.2.8. TURN THE SELECTOR VALVE ON THE FRONT PANEL TO THE CELL POSITION.

5.5.2.9. VERIFY THAT THE NEW PRESSURE DISPLAYED ON THE DIGITAL PANEL METER DOES NOT CHANGE DURING A 10-SECOND PERIOD. TAKE THE aP2 PRESSURE READING ON THE DIGITAL PANEL METER AND ENTER THAT NUMBER ON THE INSTRUMENT CALIBRATION SHEET IN APPENDIX B.2, ITEM B.2.3, AS aP2.

5.5.2.10. CALCULATE THE RATIO  $\frac{aP1}{aP2} = aP$  AND ENTER THIS VALUE AS aP ON THE INSTRUMENT CALIBRATION SHEET IN APPENDIX B.2, ITEM B.2.3.

5.5.2.11. REPEAT THE STEPS IN SECTIONS 5.5.2.2 TO 5.5.2.11 UNTIL FIVE CONSECUTIVE aP VALUES FALL WITHIN  $\pm 0.0005$  OF EACH OTHER.

NOTE: THE RATIOS CAN BE CALCULATED TO 4 DECIMAL PLACES AND ARE DIMENSIONLESS, NOT IN PSIG.

### 5.5.3. VCb LARGE CALIBRATION (56.5592 cc SPHERE)

5.5.3.1. INSTALL ONE LARGE 56.5592 cc SPHERE IN THE SAMPLE CELL AND PLACE THE SAMPLE CELL INTO THE SAMPLE CELL HOLDER. PERFORM THE STEPS LISTED IN SECTION 5.5.1. (THE PURGE ROUTINE) WITH THE LARGE CELL CONTAINING THE LARGE SPHERE.

5.5.3.2. OPEN THE TOGGLE VALVES I AND II, AND CLOSE THE GAS IN TOGGLE VALVE.

5.5.3.3. TURN THE SELECTOR VALVE ON THE FRONT PANEL TO THE CELL POSITION AND THEN OPEN THE GAS OUT TOGGLE VALVE.

5.5.3.4. TURN THE ZERO ADJUSTMENT KNOB ON THE FRONT PANEL UNTIL A 0.000 PSIG READING IS DISPLAYED ON THE DIGITAL PANEL METER.

5.5.3.5. TURN THE SELECTOR VALVE TO THE REFERENCE POSITION AND CLOSE THE GAS OUT TOGGLE VALVE.

5.5.3.6. OPEN THE GAS IN TOGGLE VALVE AND, WHEN THE DIGITAL PANEL METER READS 17.0 PSIG, CLOSE THE GAS IN TOGGLE VALVE.

5.5.3.7. VERIFY THAT THE PRESSURE DISPLAYED ON THE DIGITAL PANEL METER DOES NOT CHANGE DURING A 10-SECOND PERIOD. TAKE THE bP1 PRESSURE READING ON THE DIGITAL PANEL METER AND ENTER THAT NUMBER ON THE INSTRUMENT CALIBRATION SHEET IN APPENDIX B.2, ITEM B.2.7., AS bP1.

5.5.3.8. TURN THE SELECTOR VALVE ON THE FRONT PANEL TO THE CELL POSITION.

5.5.3.9. VERIFY THAT THE NEW PRESSURE DISPLAYED ON THE DIGITAL PANEL METER DOES NOT CHANGE DURING A 10-SECOND PERIOD. TAKE THE bP2 PRESSURE READING ON THE DIGITAL PANEL METER AND ENTER THAT NUMBER ON THE INSTRUMENT CALIBRATION SHEET IN APPENDIX B.2, ITEM B.2.7, AS bP2.

5.5.3.10. CALCULATE THE RATIO  $\frac{bP1}{bP2} = bP$  AND ENTER THIS VALUE AS bP ON THE INSTRUMENT CALIBRATION SHEET IN APPENDIX B.2, ITEM B.2.7.

5.5.3.11. REPEAT THE STEPS IN SECTIONS 5.5.3.2 TO 5.5.3.11 UNTIL FIVE CONSECUTIVE bP VALUES FALL WITHIN  $\pm 0.0005$  OF EACH OTHER.

#### 5.5.4. CALCULATION OF VR LARGE AND VC LARGE VOLUMES

5.5.4.1. FILL IN THE CORRESPONDING CALCULATION SHEET ON APPENDIX B.2., ITEMS B.2.11. AND B.2.12.

$$VR\ LARGE = \frac{56.5592\ cc\ [V\ SPHERE]}{(a - 1) - (b - 1)} = \frac{56.5592}{(a - b)}$$

$$VC\ LARGE = VR\ LARGE \times (a - 1)$$

#### 5.5.5. LARGE SPHERE RUN

5.5.1. INSTALL ONE LARGE 56.5592 cc SPHERE IN THE SAMPLE CELL CUP AND PLACE BOTH INTO THE CELL HOLDER. ( THIS IS EQUIVALENT TO FILLING THE LARGE CUP WITH THE SPHERE INDICATED AS THE SAMPLE.) PERFORM THE STEPS LISTED IN SECTION 5.6.1. (THE PURGE ROUTINE ) WITH THE LARGE CELL FILLED.

5.5.2. OPEN THE TOGGLE VALVES I AND II AND CLOSE THE GAS IN TOGGLE VALVE.

5.5.3. TURN THE SELECTOR VALVE ON THE FRONT PANEL TO THE CELL POSITION AND THEN OPEN THE GAS OUT TOGGLE VALVE.

5.5.4. TURN THE ZERO ADJUSTMENT KNOB ON THE FRONT PANEL UNTIL A 0.000 PSIG READING IS DISPLAYED ON THE DIGITAL PANEL METER. CLOSE THE GAS OUT TOGGLE VALVE.

5.5.5. TURN THE SELECTOR VALVE TO THE REFERENCE POSITION AND CLOSE THE GAS OUT TOGGLE VALVE.

5.5.6. OPEN THE GAS IN TOGGLE VALVE AND, WHEN THE DIGITAL PANEL METER READS 17.0 PSIG, CLOSE THE GAS IN TOGGLE VALVE.

5.5.7. VERIFY THAT THE PRESSURE DISPLAYED ON THE DIGITAL PANEL METER DOES NOT CHANGE DURING A 10-SECOND PERIOD. TAKE THE P1 PRESSURE READING ON THE DIGITAL PANEL METER AND ENTER THAT NUMBER ON THE LARGE SPHERE RUN DATA SHEET (APPENDIX C, ITEM C.1.2.).

5.5.8. TURN THE SELECTOR VALVE ON THE FRONT PANEL TO THE CELL POSITION.

5.5.9. VERIFY THAT THE NEW PRESSURE DISPLAYED ON THE DIGITAL PANEL METER DOES NOT CHANGE DURING A 10-SECOND PERIOD. TAKE THE P2 PRESSURE READING ON THE DIGITAL PANEL METER AND ENTER THAT NUMBER ON THE LARGE SPHERE RUN DATA SHEET (APPENDIX C, ITEM C.1.2.).

5.5.10. CALCULATE  $VP = VC - VR \times ((P1/P2) - 1)$ , WITH NUMBERS FOR VC AND VR TAKEN FROM THE CALIBRATION SECTION. VERIFY THAT THE CALCULATED VALUES ARE WITHIN 0.4 % OF THE EXPECTED VOLUME OF 56.5592 cc. THE UPPER LIMIT IS 56.7854 cc AND THE LOWER LIMIT IS 56.3330 cc.

### 5.5.6. VRc SMALL CALIBRATION (NO SPHERES, LARGE CELL)

5.5.6.1. PERFORM THE STEPS LISTED IN SECTION 5.5.1 (THE PURGE ROUTINE) WITH THE LARGE SAMPLE CELL IN THE CELL HOLDER.

5.5.6.2. CLOSE TOGGLE VALVES I AND GAS IN. OPEN VALVE II.

5.5.6.3. TURN THE SELECTOR VALVE ON THE FRONT PANEL TO THE CELL POSITION AND THEN OPEN THE GAS OUT TOGGLE VALVE.

5.5.6.4. TURN THE ZERO ADJUSTMENT KNOB ON THE FRONT PANEL UNTIL A 0.000 PSIG READING IS DISPLAYED ON THE DIGITAL PANEL METER. CLOSE THE GAS OUT TOGGLE VALVE.

5.5.6.5. TURN THE SELECTOR VALVE TO THE REFERENCE POSITION AND CLOSE THE GAS OUT TOGGLE VALVE.

5.5.6.6. OPEN THE GAS IN TOGGLE VALVE AND, WHEN THE DIGITAL PANEL METER READS 17.0 PSIG, CLOSE THE GAS IN TOGGLE VALVE.

5.5.6.7. VERIFY THAT THE PRESSURE DISPLAYED ON THE DIGITAL PANEL METER DOES NOT CHANGE DURING A 10-SECOND PERIOD. TAKE THE cP1 PRESSURE READING ON THE DIGITAL PANEL METER AND ENTER THAT NUMBER ON THE INSTRUMENT CALIBRATION SHEET IN APPENDIX B.3, ITEM B.3.3., AS cP1.

5.5.6.8. TURN THE SELECTOR VALVE ON THE FRONT PANEL TO THE CELL POSITION.

5.5.6.9. VERIFY THAT THE NEW PRESSURE DISPLAYED ON THE DIGITAL PANEL METER DOES NOT CHANGE DURING A 10-SECOND PERIOD. TAKE THE cP2 PRESSURE READING ON THE DIGITAL PANEL METER AND ENTER THAT NUMBER ON THE INSTRUMENT CALIBRATION SHEET IN APPENDIX B.3, ITEM B.3.3, AS cP2.

5.5.6.10. CALCULATE THE RATIO  $\frac{cP1}{cP2} = cP$  AND ENTER THIS VALUE AS cP ON THE INSTRUMENT CALIBRATION SHEETS IN APPENDIX B.3, ITEM B.3.3.

5.5.6.11. REPEAT THE STEPS IN SECTIONS 5.5.5.2 TO 5.5.5.11 UNTIL FIVE CONSECUTIVE cP VALUES FALL WITHIN +/-0.005 OF EACH OTHER.

### 5.5.7. Vcd SMALL CALIBRATION ( NO SPHERES, SMALL CELL)

5.5.7.1. INSTALL ONE SMALL SLEEVE AND ITS SAMPLE CELL CUP INTO THE CELL HOLDER. PERFORM THE STEPS LISTED IN SECTION 5.5.1. ( THE PURGE ROUTINE ) WITH THE CELL EMPTY.

5.5.7.2. CLOSE VALVES I AND GAS IN. OPEN VALVE II.

5.5.7.3. TURN THE SELECTOR VALVE ON THE FRONT PANEL TO THE CELL POSITION AND THEN OPEN THE GAS OUT TOGGLE VALVE.

5.5.7.4. TURN THE ZERO ADJUSTMENT KNOB ON THE FRONT PANEL UNTIL A 0.000 PSIG READING IS DISPLAYED ON THE DIGITAL PANEL METER. CLOSE THE GAS OUT TOGGLE VALVE.

5.5.7.5. TURN THE SELECTOR VALVE TO THE REFERENCE POSITION AND CLOSE THE GAS OUT TOGGLE VALVE.

5.5.7.6. OPEN THE GAS IN TOGGLE VALVE AND, WHEN THE DIGITAL PANEL METER READS 17.0 PSIG, CLOSE THE GAS IN TOGGLE VALVE.

5.5.7.7. VERIFY THAT THE PRESSURE DISPLAYED ON THE DIGITAL PANEL METER DOES NOT CHANGE DURING A 10-SECOND PERIOD. TAKE THE dP1 PRESSURE READING ON THE DIGITAL PANEL METER AND ENTER THAT NUMBER ON THE INSTRUMENT CALIBRATION SHEET IN APPENDIX B.3, ITEM B.3.7., AS dP1.

5.5.6.8. TURN THE SELECTOR VALVE ON THE FRONT PANEL TO THE CELL POSITION.

5.5.7.9. VERIFY THAT THE NEW PRESSURE DISPLAYED ON THE DIGITAL PANEL METER DOES NOT CHANGE DURING A 10-SECOND PERIOD. TAKE THE dP2 PRESSURE READING ON THE DIGITAL PANEL METER AND ENTER THAT NUMBER ON THE INSTRUMENT CALIBRATION SHEET IN APPENDIX B.3, ITEM B.3.7, AS dP2.

5.5.7.10. CALCULATE THE RATIO  $\frac{dP1}{dP2} = dP$  AND ENTER THIS VALUE AS dP ON THE INSTRUMENT CALIBRATION SHEET IN APPENDIX B.3, ITEM B.3.7.

5.5.7.11. REPEAT THE STEPS IN SECTIONS 5.5.6.2 TO 5.5.6.11 UNTIL FIVE CONSECUTIVE dP VALUES FALL WITHIN +/-0.0005 OF EACH OTHER.

### 5.5.8. CALCULATION OF VR SMALL AND VC SMALL VOLUMES

5.5.8.1. FILL IN THE CORRESPONDING CALCULATION SHEET ON APPENDIX B.3., ITEMS B.3.11 AND B.3.12.

$$VR\ SMALL = \frac{VC\ LARGE}{(c - 1)} \qquad VC\ SMALL = VR\ SMALL \times (d - 1)$$

### 5.6.3. SMALL SPHERE RUN

5.6.3.1. INSTALL ONE SMALL SPHERE (7.0699 cc) AND TWO MICRO SPHERES (2.145 cc) IN THE SAMPLE CELL CUP. ( THIS IS EQUIVALENT TO FILLING THE SMALL CUP WITH THE SPHERE INDICATED AS THE SAMPLE.) PLACE THE SAMPLE CELL CUP INTO ITS SLEEVE AND THEN THE SLEEVE INTO THE CELL HOLDER. PERFORM THE STEPS LISTED IN SECTION 5.6.1. (THE PURGE ROUTINE) WITH THE SMALL CELL FILLED.

5.6.3.2. CLOSE ALL THE TOGGLE VALVES. OPEN THE TOGGLE VALVE II.

5.6.3.3. TURN THE SELECTOR VALVE ON THE FRONT PANEL TO THE CELL POSITION AND THEN OPEN THE GAS OUT TOGGLE VALVE.

5.6.3.4. TURN THE ZERO ADJUSTMENT KNOB ON THE FRONT PANEL UNTIL A 0.000 PSIG READING IS DISPLAYED ON THE DIGITAL PANEL METER. CLOSE THE GAS OUT TOGGLE VALVE.

5.6.3.5. TURN THE SELECTOR VALVE TO THE REFERENCE POSITION AND CLOSE THE GAS OUT TOGGLE VALVE.

5.6.3.6. OPEN THE GAS IN TOGGLE VALVE AND, WHEN THE DIGITAL PANEL METER READS 17.0 PSIG, CLOSE THE GAS IN TOGGLE VALVE.

5.6.3.7. VERIFY THAT THE PRESSURE DISPLAYED ON THE DIGITAL PANEL METER DOES NOT CHANGE DURING A 10-SECOND PERIOD. TAKE THE P1 PRESSURE READING ON THE DIGITAL PANEL METER AND ENTER THAT NUMBER ON THE SMALL SPHERE RUN DATA SHEET (APPENDIX C, ITEM C.1.3.).

5.6.3.8. TURN THE SELECTOR VALVE ON THE FRONT PANEL TO THE CELL POSITION.

5.6.3.9. VERIFY THAT THE NEW PRESSURE DISPLAYED ON THE DIGITAL PANEL METER DOES NOT CHANGE DURING A 10-SECOND PERIOD. TAKE THE P2 PRESSURE READING ON THE DIGITAL PANEL METER AND ENTER THAT NUMBER ON THE SMALL SPHERE RUN DATA SHEET (APPENDIX C, ITEM C.1.3.).

5.6.3.10. CALCULATE  $VP = VC - VR \times ((P1/P2) - 1)$ , WITH NUMBERS FOR VC AND VR TAKEN FROM THE CALIBRATION SECTION. VERIFY THAT THE CALCULATED VALUES ARE WITHIN 0.7 % OF THE EXPECTED VOLUME OF 9.2149 cc. THE UPPER LIMIT IS 9.2794 cc AND THE LOWER LIMIT IS 9.1504 cc

#### **5.6.4. VRe MICRO CALIBRATION (NO SPHERES, MICRO CELL & MICRO SLEEVE)**

5.6.4.1. PERFORM THE STEPS LISTED IN SECTION 5.4.1. ( THE PURGE ROUTINE ) WITH THE EMPTY MICRO CELL IN PLACE.

5.6.4.2. CLOSE ALL THE TOGGLE VALVES .

5.6.4.3. TURN THE SELECTOR VALVE ON THE FRONT PANEL TO THE CELL POSITION AND THEN OPEN THE GAS OUT TOGGLE VALVE.

5.6.4.4. TURN THE ZERO ADJUSTMENT KNOB ON THE FRONT PANEL UNTIL A 0.000 PSIG READING IS DISPLAYED ON THE DIGITAL PANEL METER. CLOSE THE GAS OUT TOGGLE VALVE.

5.6.4.5. TURN THE SELECTOR VALVE TO THE REFERENCE POSITION AND CLOSE THE GAS OUT TOGGLE VALVE.

5.6.4.6. OPEN THE GAS IN TOGGLE VALVE AND, WHEN THE DIGITAL PANEL METER READS 17.0 PSIG, CLOSE THE GAS IN TOGGLE VALVE.

5.6.4.7. VERIFY THAT THE PRESSURE DISPLAYED ON THE DIGITAL PANEL METER DOES NOT CHANGE DURING A 10-SECOND PERIOD. TAKE THE eP1 PRESSURE READING ON THE DIGITAL PANEL METER AND ENTER THAT NUMBER ON THE INSTRUMENT CALIBRATION SHEET IN APPENDIX B.4, ITEM B.4.3., AS eP1.

5.6.4.8. TURN THE SELECTOR VALVE ON THE FRONT PANEL TO THE CELL POSITION.

5.6.4.9. VERIFY THAT THE NEW PRESSURE DISPLAYED ON THE DIGITAL PANEL METER DOES NOT CHANGE DURING A 10-SECOND PERIOD. TAKE THE eP2 PRESSURE READING ON THE DIGITAL PANEL METER AND ENTER THAT NUMBER ON THE INSTRUMENT CALIBRATION SHEET IN APPENDIX B.4, ITEM B.4.3, AS eP2.

5.6.4.10. CALCULATE THE RATIO  $\frac{eP1}{eP2} = eP$  AND ENTER THIS VALUE AS eP ON THE INSTRUMENT CALIBRATION SHEET IN APPENDIX B.4, ITEM B.4.3.

5.6.4.11. REPEAT THE STEPS IN SECTIONS 5.5.8.2 TO 5.5.8.11 UNTIL FIVE CONSECUTIVE eP VALUES FALL WITHIN  $\pm 0.0005$  OF EACH OTHER.

#### **5.7. VCf MICRO CALIBRATION ( 2.145 cc, TWO MICRO SPHERES )**

5.7.1. INSTALL TWO MICRO 1.0725 cc SPHERES, THEIR CUP AND SLEEVE IN THE CELL HOLDER. PERFORM THE STEPS LISTED IN SECTION 5.5.1. ( THE PURGE ROUTINE ) WITH THE CELL HOLDER FILLED AS INDICATED ABOVE.

5.7.2. CLOSE ALL THE TOGGLE VALVES.

5.7.3. TURN THE SELECTOR VALVE ON THE FRONT PANEL TO THE CELL POSITION AND THEN OPEN THE GAS OUT TOGGLE VALVE.

5.7.4. TURN THE ZERO ADJUSTMENT KNOB ON THE FRONT PANEL UNTIL A 0.000 PSIG READING IS DISPLAYED ON THE DIGITAL PANEL METER. CLOSE THE GAS OUT TOGGLE VALVE.

5.7.5. TURN THE SELECTOR VALVE TO THE REFERENCE POSITION AND CLOSE THE GAS OUT TOGGLE VALVE.

5.7.6. OPEN THE GAS IN TOGGLE VALVE AND, WHEN THE DIGITAL PANEL METER READS 17.0 PSIG, CLOSE THE GAS IN TOGGLE VALVE.

5.7.7. VERIFY THAT THE PRESSURE DISPLAYED ON THE DIGITAL PANEL METER DOES NOT CHANGE DURING A 10-SECOND PERIOD. TAKE THE fp1 PRESSURE READING ON THE DIGITAL PANEL METER AND ENTER THAT NUMBER ON THE INSTRUMENT CALIBRATION SHEET IN APPENDIX B.4, ITEM B.4.7., AS fp1.

5.7.8. TURN THE SELECTOR VALVE ON THE FRONT PANEL TO THE CELL POSITION.

5.7.9. VERIFY THAT THE NEW PRESSURE DISPLAYED ON THE DIGITAL PANEL METER DOES NOT CHANGE DURING A 10-SECOND PERIOD. TAKE THE fp2 PRESSURE READING ON THE DIGITAL PANEL METER AND ENTER THAT NUMBER ON THE INSTRUMENT CALIBRATION SHEET IN APPENDIX B.4, ITEM B.4.7, AS fp2.

5.7.10. CALCULATE THE RATIO  $\frac{fp1}{fp2} = fp$  AND ENTER THIS VALUE AS fp ON THE INSTRUMENT CALIBRATION SHEET IN APPENDIX B.4, ITEM B.4.7.

5.7.11. REPEAT THE STEPS IN SECTIONS 5.5.9.2 TO 5.5.9.11 UNTIL FIVE CONSECUTIVE fp VALUES FALL WITHIN  $\pm 0.0005$  OF EACH OTHER.

## **5.8. CALCULATION OF VR MICRO AND VC MICRO VOLUMES**

5.8.1. FILL IN THE CORRESPONDING CALCULATION SHEET ON APPENDIX B.4., ITEMS B.4.11 AND B.4.12.

$$VR\ MICRO = \frac{2.145\ cc}{(e - 1) - (f - 1)} = \frac{2.145}{(e - f)}$$

$$VC\ MICRO = VR\ MICRO \times (e - 1)$$



## 5.9. MICRO SPHERE RUN

5.9.1. INSTALL TWO MICRO SPHERES, EACH WITH A VOLUME OF 1.0725 cc IN THE CELL CUP. (THIS IS EQUIVALENT TO FILLING THE MICRO CUP WITH THE SPHERE INDICATED AS THE SAMPLE.) PERFORM THE STEPS LISTED IN SECTION 5.6.1. (THE PURGE ROUTINE) WITH THE SMALL CELL FILLED.

5.9.2. CLOSE ALL THE TOGGLE VALVES.

5.9.3. TURN THE SELECTOR VALVE ON THE FRONT PANEL TO THE CELL POSITION AND THEN OPEN THE GAS OUT TOGGLE VALVE.

5.9.4. TURN THE ZERO ADJUSTMENT KNOB ON THE FRONT PANEL UNTIL A 0.000 PSIG READING IS DISPLAYED ON THE DIGITAL PANEL METER. CLOSE THE GAS OUT TOGGLE VALVE.

5.9.5. TURN THE SELECTOR VALVE TO THE REFERENCE POSITION AND CLOSE THE GAS OUT TOGGLE VALVE.

5.9.6. OPEN THE GAS IN TOGGLE VALVE AND, WHEN THE DIGITAL PANEL METER READS 17.0 PSIG, CLOSE THE GAS IN TOGGLE VALVE.

5.9.7. VERIFY THAT THE PRESSURE DISPLAYED ON THE DIGITAL PANEL METER DOES NOT CHANGE DURING A 10-SECOND PERIOD. TAKE THE **P1** PRESSURE READING ON THE DIGITAL PANEL METER AND ENTER THAT NUMBER ON THE MICRO SPHERE RUN DATA SHEET (APPENDIX C, ITEM C.1.4.).

5.9.8. TURN THE SELECTOR VALVE ON THE FRONT PANEL TO THE CELL POSITION.

5.9.9. VERIFY THAT THE NEW PRESSURE DISPLAYED ON THE DIGITAL PANEL METER DOES NOT CHANGE DURING A 10-SECOND PERIOD. TAKE THE P2 PRESSURE READING ON THE DIGITAL PANEL METER AND ENTER THAT NUMBER ON THE MICRO SPHERE RUN DATA SHEET (APPENDIX C, ITEM C.1.4.).

5.9.10. CALCULATE  $VP = VC - VR \times ((P1/P2) - 1)$  WITH NUMBERS FOR VC AND VR TAKEN FROM THE CALIBRATION SECTION. VERIFY THAT THE CALCULATED VALUES ARE WITHIN 0.5 % OF THE EXPECTED VOLUME OF 2.145 cc. THE UPPER LIMIT IS 2.1557 cc AND THE LOWER LIMIT IS 2.1343 cc.

## **6.0. REFERENCES**

- 6.1. S. LOWELL AND J.E. SHIELDS, “ POWDER SURFACE AREA AND POROSITY”, 3RD ED., CHAPMAN AND HALL, NY (1991).
- 6.2. QUANTACHROME MULTIPYCNOMETER OPERATION MANUAL, PART NUMBER 05034.
- 6.3. MECHANICAL ASSEMBLY DIAGRAM BM114-1618-2 ( THREE SHEETS).
- 6.4. ELECTRICAL ASSEMBLY DIAGRAM BM114-1618-1 (ONE SHEET).
- 6.5. QUANTACHROME SCHEMATIC AND WIRING DIAGRAM , DRAWING NUMBER C000-0094.

## **APPENDIX A**

### **A.1. MODIFICATIONS AND REVISIONS.**

**A.1.1. MODIFICATIONS FOR USE WITH ALL MULTIPYCNOMETER MODELS ARE LISTED BELOW.**

DATE	MODEL	MODIFICATION	APPROVED BY
6/20/95	MVP-2	DIGITAL FRONT PANEL METER CHANGED , ONLY AFFECTED THE MODEL	D.J.S C.B
10/29/96	MVP-3	CUT AWAY CELL, ONLY AFFECTED THE MODEL	D.S

## APPENDIX B

## B.1. INSTRUMENT CHECK SHEET

**B.1.1. THIS INSTRUMENT CHECK SHEET IS TO BE FILLED COMPLETELY BY THE TECHNICIAN OR OPERATOR INVOLVED WHEN FULLY TESTING THE MULTIPYCNOMETER.**

### B.1.2.1. OPERATOR

**B.1.2.2. DATE** \_\_\_\_\_

### B.1.2.3. MODEL

#### B.1.2.4. SERIAL NUMBER

**B.1.3.ADD TICK MARKS TO CONFIRM THAT THE STEPS OUTLINED IN THE SECTIONS INDICATED BELOW HAVE BEEN CARRIED OUT SATISFACTORILY.**

### B.1.3.1. ELECTRICAL CHECKS (SECTION 5.1.1.)

### B.1.3.2. MECHANICAL CHECKS (SECTION 5.1.2.)

### B.1.3.3. AC CHECKS (SECTION 5.2.1.)

<b>B.1.3.4.</b>	<b>DC CHECKS (SECTION 5.2.2.)</b>	<b>24.00+/-0.01 VDC</b>	<u>                    </u>
		<b>5.00+/-0.01 VDC</b>	<u>                    </u>

**B.1.3.5. DIGITAL PANEL METER (SECTION 5.3.1.) 0.0000 PSIG\_\_\_\_\_**

**B.1.3.6. PRESSURE RELIEF VALVE (SECTION 5.3.2.) 25 PSIG**

**B.1.3.7. LEAK TEST PURGE ( SECTION 5.4.1.) 30 MINUTE \_\_\_\_\_**

LEAK TEST	5.4.2. MICRO	5.4.3. SMALL	5.4.4. LARGE	5.4.5 CELL	5.4.6. FOUR WAY
STARTING PRESSURE					
PRESSURE AFTER 1 MINUTE					
TOTAL a =					

**TOTAL a = STARTING PRESSURE - PRESSURE AFTER 1 MINUTE.**

**B.1.3.8. TOTAL PSIG DIFFERENTIAL LEAK RATE SHOULD BE NO GREATER THEN 0.004 PSIG FOR EACH OF THE MICRO, SMALL, LARGE, CELL AND FOUR WAY SECTIONS.**

## **APPENDIX B**

### **B.2. INSTRUMENT CALIBRATION SHEET FOR THE LARGE CELL**

**B.2.1. THIS INSTRUMENT CALIBRATION SHEET IS TO BE FILLED COMPLETELY BY THE TECHNICIAN OR OPERATOR INVOLVED WHEN FULLY CALIBRATING THE MULTIPYCNOMETER.**

**B.2.2.1. OPERATOR** \_\_\_\_\_

**B.2.2.2. DATE** \_\_\_\_\_

**B.2.2.3. MODEL** \_\_\_\_\_

**B.2.2.4. SERIAL NUMBER** \_\_\_\_\_

**B.2.3. VRa LARGE'S aP1 AND aP2 ARE THE PRESSURES BEFORE AND AFTER EXPANSION (SECTION 5.5.2 ), RESPECTIVELY.**

#	aP1	÷	aP2	=	aP
1		÷		=	
2		÷		=	
3		÷		=	
4		÷		=	
5		÷		=	

$$a = \text{TOTAL}a \text{_____} \div 5 = \text{_____}$$

**B.2.4. COLUMN aP LISTS FIVE CONSECUTIVE PASSES OF ITEMS THE aP RATIO MUST FALL WITHIN +/-0.0005 OF EACH OTHER BEFORE THEIR SUM CAN BE AVERAGED.**

**B.2.5. TOTALa IS THE SUM OF FIVE CONSECUTIVE aP READINGS. ENTER THE SUM AS TOTALa IN SECTION B.2.3.**

**B.2.6. a IS THE AVERAGE OF FIVE CONSECUTIVE aP VALUES.**

**B.2.7. VCb LARGE'S bP1 AND bP2 ARE THE PRESSURES BEFORE AND AFTER EXPANSION (SECTION 5.5.3 ), RESPECTIVELY.**

#	bP1	÷	bP2	=	bP
1		÷		=	
2		÷		=	
3		÷		=	
4		÷		=	
5		÷		=	

$$b = \text{TOTAL}b \text{_____} \div 5 = \text{_____}$$

**B.2.8. COLUMN bP LISTS FIVE CONSECUTIVE PASSES OF ITEMS THE bP RATIO MUST FALL WITHIN +/-0.0005 OF EACH OTHER BEFORE THEIR SUM CAN BE AVERAGED.**

**B.2.9. TOTALb IS THE SUM OF FIVE CONSECUTIVE bP READINGS. ENTER THE SUM AS TOTALb IN SECTION B.2.7.**

**B.2.10. b IS THE AVERAGE OF FIVE CONSECUTIVE bP VALUES.**

**B.2.11. VR LARGE** \_\_\_\_\_ =  $\frac{56.5592 \text{ cc ( SPHERE )}}{(a - b)}$  =  $\frac{56.5592}{(\text{ } - \text{ })}$

**B.2.12. VC LARGE** \_\_\_\_\_ = VR LARGE \_\_\_\_\_  $\times \frac{(a - 1)}{\text{ }}$

### **B.3. INSTRUMENT CALIBRATION SHEET FOR THE SMALL CELL**

**B.3.1. THIS INSTRUMENT CALIBRATION SHEET IS TO BE FILLED COMPLETELY BY THE TECHNICIAN OR OPERATOR INVOLVED WHEN FULLY CALIBRATING THE MULTIPYCNOMETER.**

**B.3.2.1. OPERATOR** \_\_\_\_\_

**B.3.2.2. DATE** \_\_\_\_\_

**B.3.2.3. MODEL** \_\_\_\_\_

**B.3.2.4. SERIAL NUMBER** \_\_\_\_\_

**B.3.3. VCc SMALL'S cP1 AND cP2 ARE THE PRESSURES BEFORE AND AFTER EXPANSION , RESPECTIVELY.**

#	cP1	÷	cP2	=	cP
1		÷		=	
2		÷		=	
3		÷		=	
4		÷		=	
5		÷		=	

**c** = TOTALc \_\_\_\_\_ ÷ 5 = \_\_\_\_\_

**B.3.4. COLUMN cP LISTS FIVE CONSECUTIVE PASSES OF ITEMS. THE cP RATIO MUST FALL WITHIN +/-0.0005 OF EACH OTHER BEFORE THEIR SUM CAN BE AVERAGED.**

**B.3.5. TOTAL<sub>c</sub> IS THE SUM OF FIVE CONSECUTIVE cP READINGS. ENTER THE SUM AS TOTAL<sub>c</sub> IN SECTION B.3.3.**

**B.3.6. c IS THE AVERAGE OF FIVE CONSECUTIVE cP VALUES.**

**B.3.7. VCd SMALL'S dP1 AND dP2 ARE THE PRESSURES BEFORE AND AFTER EXPANSION RESPECTIVELY.**

#	dP1	÷	dP2	=	dP
1		÷		=	
2		÷		=	
3		÷		=	
4		÷		=	
5		÷		=	

$$d = \text{TOTALd} \div 5 =$$

**B.3.8. COLUMN dP LISTS FIVE CONSECUTIVE PASSES OF ITEMS THE dP RATIO MUST FALL WITHIN +/-0.0005 OF EACH OTHER BEFORE THEIR SUM CAN BE AVERAGED.**

**B.3.9. TOTAL<sub>d</sub> IS THE SUM OF FIVE CONSECUTIVE dP READINGS. ENTER THE SUM AS TOTAL<sub>d</sub> IN SECTION B.3.7.**

**B.3.10. d IS THE AVERAGE OF FIVE CONSECUTIVE dP VALUES.**

$$\text{B.3.11. VR SMALL} = \frac{\text{VC large}}{(c - 1)} = \frac{\text{VC LARGE}}{(d - 1)}$$

$$\text{B.3.12. VC SMALL} = \text{VR SMALL} \times (d - 1)$$

#### B.4. INSTRUMENT CALIBRATION SHEET FOR THE MICRO CELL

**B.4.1. THIS INSTRUMENT CALIBRATION SHEET IS TO BE FILLED COMPLETELY BY THE TECHNICIAN OR OPERATOR INVOLVED WHEN FULLY CALIBRATING THE MULTIPYCNOMETER.**

**B.4.2.1. OPERATOR** \_\_\_\_\_

**B.4.2.2. DATE** \_\_\_\_\_

**B.4.2.3. MODEL** \_\_\_\_\_

**B.4.2.4. SERIAL NUMBER** \_\_\_\_\_

**B.4.3. VCe MICRO'S eP1 AND eP2 ARE THE PRESSURES BEFORE AND AFTER EXPANSION RESPECTIVELY.**

#	eP1	÷	eP2	=	eP
1		÷		=	
2		÷		=	
3		÷		=	
4		÷		=	
5		÷		=	

$$e = \text{TOTAL}e \text{_____} \div 5 = \text{_____}$$

**\_B.4.4. COLUMN eP LISTS FIVE CONSECUTIVE PASSES OF ITEMS. THE eP RATIO MUST FALL WITHIN +/-0.0005 OF EACH OTHER BEFORE THEIR SUM CAN BE AVERAGED.**

**B.4.5. TOTALe IS THE SUM OF FIVE CONSECUTIVE eP READINGS. ENTER THE SUM AS TOTALe IN SECTION B.4.3.**

**B.4.6. e IS THE AVERAGE OF FIVE CONSECUTIVE eP VALUES.**



**B.4.7. VCf MICRO'S fp1 AND fp2 ARE THE PRESSURES BEFORE AND AFTER EXPANSION (SECTION 5.5.9), RESPECTIVELY.**

#	fp1	÷	fp2	=	fp
1		÷		=	
2		÷		=	
3		÷		=	
4		÷		=	
5		÷		=	

$$f = \text{TOTALf} \underline{\hspace{2cm}} \div 5 = \underline{\hspace{2cm}}$$

**B.4.8. COLUMN fp LISTS FIVE CONSECUTIVE PASSES OF ITEMS IN SECTION 5.5.9. THE fp RATIO MUST FALL WITHIN +/-0.0005 OF EACH OTHER BEFORE THEIR SUM CAN BE AVERAGED.**

**B.4.9. TOTALf IS THE SUM OF FIVE CONSECUTIVE fp READINGS. ENTER THE SUM AS TOTALf IN SECTION B.4.7.**

**B.4.10. f IS THE AVERAGE OF FIVE CONSECUTIVE fp VALUES.**

$$\text{B.4.11. VR MICRO} \underline{\hspace{2cm}} = \frac{2.145 \text{ cc ( SPHERE )}}{(e - f)} = \frac{2.145 \text{ cc}}{(\underline{\hspace{1cm}}) - (\underline{\hspace{1cm}})}$$

$$\text{B.4.12. VC MICRO} \underline{\hspace{2cm}} = \text{VR MICRO} \underline{\hspace{2cm}} \times \frac{(e - 1)}{\underline{\hspace{2cm}}}$$

## APPENDIX C

### **C.1 SPHERE RUNS' DATA SHEETS**

**C.1.1 THIS INSTRUMENT RUN DATA SHEET IS TO BE FILLED COMPLETELY BY THE TECHNICIAN OR OPERATOR INVOLVED AFTER FULLY CALIBRATING THE MULTIPYCNOMETER. NOTE THAT THE WORKING EQUATION FOR THE MULTIPYCNOMETER IS  $VP = VC - VR [P1/P2]$ , WHERE VP IS THE SPHERE OR SAMPLE VOLUME.**

**C.1.2. LARGE SPHERE RUN (SAMPLE VOLUME VP = 56.5592 cc). DATA ARE TO BE TAKEN FROM SECTION 5.6.2. AND ENTERED BELOW.**

$$P \underline{\hspace{2cm}} = P1 \underline{\hspace{2cm}} \div P2 \underline{\hspace{2cm}}$$

$$PVR_{LARGE} \underline{\hspace{2cm}} = P \underline{\hspace{2cm}} \times VR_{LARGE} \underline{\hspace{2cm}}$$

$$PVR \underline{\hspace{2cm}} = PVR_{LARGE} \underline{\hspace{2cm}} - 1$$

$$VP \underline{\hspace{2cm}} = VC \underline{\hspace{2cm}} - PVR \underline{\hspace{2cm}}$$

**VP (+/-0.4%): UPPER LIMIT, 56.7854 cc ; LOWER LIMIT, 56.3330 cc.**

**C.1.3. SMALL SPHERE RUN (SAMPLE VOLUME VP = 9.2149 cc). DATA ARE TO BE TAKEN FROM SECTION 5.6.3. AND ENTERED BELOW.**

$$P \underline{\hspace{2cm}} = P1 \underline{\hspace{2cm}} \div P2 \underline{\hspace{2cm}}$$

$$PVR_{SMALL} \underline{\hspace{2cm}} = P \underline{\hspace{2cm}} \times VR_{SMALL} \underline{\hspace{2cm}}$$

$$PVR \underline{\hspace{2cm}} = PVR_{SMALL} \underline{\hspace{2cm}} - 1$$

$$VP \underline{\hspace{2cm}} = VC \underline{\hspace{2cm}} - PVR \underline{\hspace{2cm}}$$

**VP (+/-0.7%): UPPER LIMIT, 9.2794 cc ; LOWER LIMIT, 9.1504 cc.**

**C.1.4. MICRO SPHERE RUN (SAMPLE VOLUME VP = 2.145 cc). DATA ARE TO BE TAKEN FROM SECTION 5.6.4. AND ENTERED BELOW.**

$$P \underline{\hspace{2cm}} = P1 \underline{\hspace{2cm}} \div P2 \underline{\hspace{2cm}}$$

$$PVR_{MICRO} \underline{\hspace{2cm}} = P \underline{\hspace{2cm}} \times VR_{MICRO} \underline{\hspace{2cm}}$$

$$PVR \underline{\hspace{2cm}} = PVR_{MICRO} \underline{\hspace{2cm}} - 1$$

$$VP \underline{\hspace{2cm}} = VC \underline{\hspace{2cm}} - PVR \underline{\hspace{2cm}}$$

**VP (+/-0.5%): UPPER LIMIT, 2.1557cc ; LOWER LIMIT, 2.1343 cc.**

## **APPENDIX D**

### **D.1. SPARE PARTS LIST**

D.1.1. THIS LIST IS PROVIDED TO ASSIST IN THE ORDERING OF REPLACEABLE PARTS FOR THE MULTIPYCNOMETER.

<b><u>PART NUMBER</u></b>	<b><u>DESCRIPTION</u></b>
<b>00131</b>	<b>MVP TRANSDUCER</b>
<b>49077</b>	<b>BALL VALVE</b>
<b>50021</b>	<b>RELIEF VALVE</b>
<b>50045</b>	<b>TOGGLE VALVE</b>
<b>00003</b>	<b>PRINTED CIRCUIT BOARD</b>
<b>15009-1100</b>	<b>1K ZERO POTENTIOMETER</b>
<b>20032</b>	<b>DIGITAL PANEL METER</b>
<b>30041</b>	<b>POWER SUPPLY</b>
<b>01500-MICRO</b>	<b>MICRO CALIBRATION. SPHERE</b>
<b>01500-LARGE</b>	<b>LARGE CALIBRATION. SPHERE</b>
<b>04000-0413</b>	<b>SMALL ALUMINUM SLEEVE</b>
<b>04000-3321</b>	<b>MICRO ALUMINUM SLEEVE</b>
<b>04000-3320</b>	<b>MICRO ALUMINUM SAMPLE CELL 4.2 cc</b>
<b>04000-0648</b>	<b>SMALL ALUMINUM SAMPLE CELL 15.0 cc</b>
<b>04000-0414</b>	<b>LARGE ALUMINUM SAMPLE CELL 130.0 cc</b>
<b>04000-0475</b>	<b>CELL HOLDER COVER</b>
<b>51000-032</b>	<b>O-RING ( CELL HOLDER COVER )</b>

## **D.2. ACCESSORY LIST**

D.2.1. THIS LIST IS PROVIDED TO ASSIST IN THE ORDERING OF ACCESSORY PARTS THAT CAN BE USED WITH A MULTIPYCNOMETER.

<b><u>PART NUMBER</u></b>	<b><u>DESCRIPTION</u></b>
<b>01500-NIST-LG</b>	<b>LARGE CALIBRATION SPHERE MEASURED BY NIST</b>
<b>01500-NIST-SM</b>	<b>SMALL CALIBRATION SPHERE MEASURED BY NIST</b>
<b>01500-MEDIUM</b>	<b>MEDIUM CALIBRATION SPHERE</b>
<b>04000-3314</b>	<b>MEDIUM ALUMINUM SAMPLE CELL 44.0 cc</b>
<b>04000-3707</b>	<b>NANO ALUMINUM SAMPLE CELL 0.26 cc</b>
<b>04000-5418</b>	<b>MESO ALUMINUM SAMPLE CELL 1.7 cc</b>
<b>04000-0414-1</b>	<b>LARGE STAINLESS STEEL SAMPLE CELL 130.0 cc</b>
<b>04000-3314-1</b>	<b>MEDIUM STAINLESS STEEL SAMPLE CELL 44.0 cc</b>
<b>04000-0648-1</b>	<b>SMALL STAINLESS STEEL SAMPLE CELL 15.0 cc</b>
<b>04000-3320-1</b>	<b>MICRO STAINLESS STEEL SAMPLE CELL 4.2 cc</b>
<b>04000-3707-1</b>	<b>NANO STAINLESS STEEL SAMPLE CELL 0.26 cc</b>
<b>01251-0414</b>	<b>LARGE ALUMINUM NON-ELUTRIATING SAMPLE CELL</b>
<b>01252-0648</b>	<b>SMALL ALUMINUM NON-ELUTRIATING SAMPLE CELL</b>
<b>01254-3314</b>	<b>MEDIUM ALUMINUM NON-ELUTRIATING SAMPLE CELL</b>
<b>01256-3320</b>	<b>MICRO ALUMINUM NON-ELUTRIATING SAMPLE CELL</b>
<b>01251-0414-1</b>	<b>LARGE STAINLESS STEEL NON-ELUTRIATING SAMPLE CELL</b>
<b>01252-0648-1</b>	<b>SMALL STAINLESS STEEL NON-ELUTRIATING SAMPLE CELL</b>
<b>01254-3314-1</b>	<b>MEDIUM STAINLESS STEEL NON-ELUTRIATING SAMPLE CELL</b>
<b>01256-3320-1</b>	<b>MICRO STAINLESS STEEL NON-ELUTRIATING SAMPLE CELL</b>
<b>75184</b>	<b>CELL LIFT OUT TOOL</b>
<b>01207</b>	<b>GAS REGULATOR</b>
<b>01003</b>	<b>1/8 INCH GAS INPUT LINE</b>
<b>05034</b>	<b>INSTRUCTION MANUAL</b>